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ISSN 0974-5904, Volume 10, No. 03

DOI:10.21276/ijee.2017.10.0311

International Journal of Earth Sciences and Engineering

June 2017, P.P. 541-544

Stabilization of Expansive Clay with Mill Scale and Lime

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Abstract: *This research paper reveals about study of Mill Scale (MS) for stabilization of soil sample. Mill Scale (MS) is extracted from iron/steel industries as waste product. This MS contains high amount of silica iron content and also lime, which acts as binding material. Basic properties of soil like Atterberg's limits, compaction characteristics and strength characteristics were determined. The soil sample was treated with different percentages of lime and optimum percentage for soil is fixed (3%) and varying percentage of MS (5%, 10%,15% and 20%) was treated with soil sample . Maximum dry density of soil decreases with increase in MS and lime content and optimum moisture content increases. The strength characteristics of the soil sample increasing up to 10% MS with 3% lime for soil sample and decreases after that. This justifies that usage of Mill Scale at 10% and 3% usage of lime gives high strength for soil.*

Key words: *Mill Scale, Lime, UCC, CBR*

1. Introduction

Soil stabilization refers to the process of changing soil properties to improve strength and durability. There are many techniques for soil stabilization, including compaction, dewatering and by adding minerals to the soil. The expansive clay has swelling and shrinkage nature during climatic change and variation in water content. Mill Scale (MS) is the material obtained from iron or steel industries as waste byproducts. This MS contains iron silica and lime which acts as binding material and give strength to the soil. This paper deals with the effect of MS and lime on strength and compaction characteristics by varying percentages of admixtures in soil. Ogundalu et.al [11] investigated the influence of steel mill scale on the strength characteristic of tropical black cotton soil on various percentages of MS 5%, 10%, 15%, 20% and 30% in order to establish the soil stabilizing potential.

Steel Mill Scale increased the unconfined compressive strength of black cotton soils by 53% at 5% Steel Mill Scale content. The results indicate that there is a potential in the use of Steel Mill Scale to strengthen Black cotton soils. Murthy [12] evaluated the mechanical properties of black cotton soil mixed with mill scale with different proportions. The mechanical properties of mill scale and black cotton soil are individually determined first and then the two are combined in varying proportions. The properties like plastic limit, California Bearing Ratio (CBR) and permeability of the same are evaluated. It was found that mixing mill scale in varying proportions of 5%, 10%, 15%, 20% increases the permeability, strength characteristics and decreases the plasticity of the soil. The CBR value of black cotton soil mixed with 15% mill scale increased three times that of the virgin black cotton soil. The permeability value of black cotton soil increased manifolds by increasing the percentage of mill scale. The plasticity of the black cotton soil decreased from 35.71% to 30.60% by adding 12% of mill scale. Zore T.D et.al [15] carried out a research work to check the improvements in the properties of clayey soil with the addition of fly ash and steel slag. Fly ash and Steel slag are blended with unmodified soil in varying percentages to obtain the optimum percentage of admixture required for the soil stabilization. CBR (Soaked) for the modified soil is increased by 180% for (40% of dry weight of soil) steel slag and 65% for (30% of dry weight of soil) fly ash. CBR (Un soaked) for the soil with different percentages of fly ash is increased by 122% for (40% of dry weight of soil) steel slag and 45% for (30% of dry weight of soil) fly ash. It is observed that addition of steel slag to clayey soil results in attainment of higher CBR value compared to Fly ash.

Table 1: *Properties of Virgin Soil Sample*

S.No	Description	Results for virgin soil sample
1	Free swell (%)	63
2	Liquid limit (%)	54
3	Plastic Limit (%)	27.64
4	Plasticity index (%)	26.36
5	Shrinkage Limit (%)	8.3
6	Specific gravity	2.53
7	Maximum dry density (g/cc)	1.39
8	Optimum moisture content (%)	23.5
9	CBR value (%)	3.85
10	UCC value (N/mm^2)	0.112
11	Grain size distribution	
	Sand (%)	22
	Silt + Clay (%)	78
12	Soil classification	CH

Received: January 12, 2017; Accepted: May 23, 2017; Published: June 30, 2017
International Journal of Earth Sciences and Engineering, 10(03), 541-544, 2017, DOI:10.21276/ijee.2017.10.0311

2. Materials

2.1Soil samples

Tests on Expansive clay sample were conducted in the present study.The strength characteristics of soil sample were determined by various tests. Soil sample was collected from the area chamadala near Andhra Pradesh.The sample was collected at a depth of 1metre from ground level and the sample obtained was completely disturbed.

2.2Admixture

Mill Scale (MS) and Lime are the admixtures used to stabilize the sample in the present investigation. MS is obtained from Iron/steel rolling mills. The MS used in this present study is collected from Rangaraj steel factory, Salem district, Tamil Nadu.

3. Methodology

The various laboratory tests were conducted on virgin soil sample as per IS standards to determine the engineering and geotechnical properties. The soil sample is mixed with various percentages of Mill Scale for a fixed percentage of lime by replacing the soil sample. For the above mentioned mixture percentages, compaction characteristics i.e., optimum moisture content and maximum dry density were determined by Standard Proctor test. Strength characteristics (Unconfined compression strength, California bearing ratio value) for corresponding optimum moisture content and maximum dry density at various curing periods were determined for the soil sample.

4. Experimental Investigation

The virgin soil sample has a degree of expansion as high based upon the free swell value. The soil sample contains 78% of particles passing through 75 micron sieve. The unconfined compressive strength values were obtained for various percentage (5, 10, 15 and 20) of mill scale and fixed 3% of lime with different curing periods were shown in Fig.1 and 2 and the values were tabulated in Table 1.

The UCC and CBR values for two different curing periods with different percentage of MS and fixed 3% of lime were tested in the laboratory and the results were obtained and tabulated in Table 2 and 3.

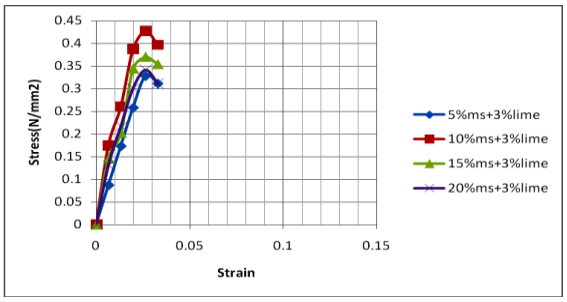

Figure 1. *Stress strain variation curve at 3 days curing period for soil sample*

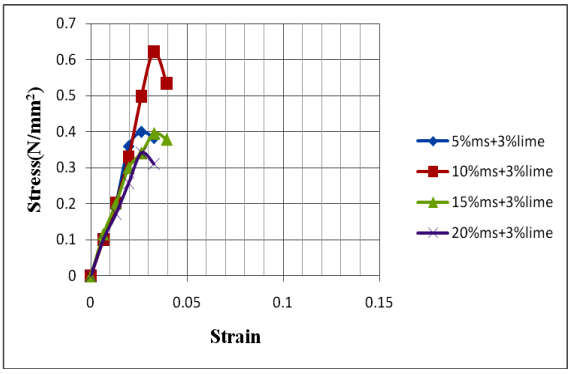

Figure 2. *Stress strain variation curve at 14 days curing for soil sample*

Table 2. *UCC values with curing periods for soil sample*

Percentage of MS+3%Lime	UCC(N/mm^2)	
	3 Days	14 Days
5	0.327	0.399
10	0.427	0.622
15	0.370	0.396
20	0.342	0.342

5. Results and Discussion

From the Table 1 it was observed that the plasticity index value is greater than 17, hence it is said to be highly plastic soil.The plasticity of soil decreases by increasing the amount of MS. The shrinkage limit is 8.3, hence the degree of expansion is high. The UCC value for soil sample treated with admixtures at 3 days curing increased up to 10% and then decreases and for 14 days curing the value increases about 46% at 10% and then decreases. The graph showing the load penetration curve is shown in Fig.3 and 4.From the table 3 it was clearly observed that the CBR value for soil sample treated with admixtures at 3 days curing was 18.7 and for 14 days curing the value was 25.46.It was much higher than the virgin soil sample. The test results shown in the fig.3 and 4 indicate that there is appreciable increase in strength with the addition of admixture to stabilize the soil sample.

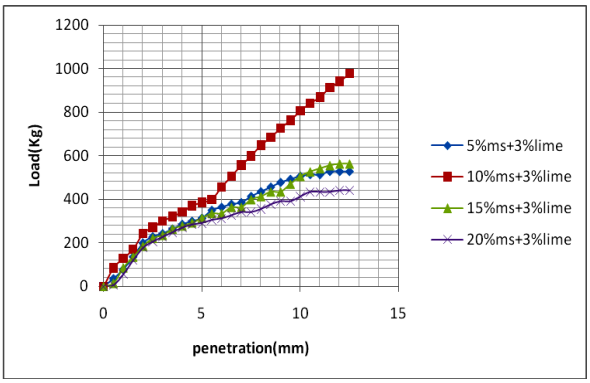

Figure 3. *Load Penetration variation curve at 3 days curing for soil sample*

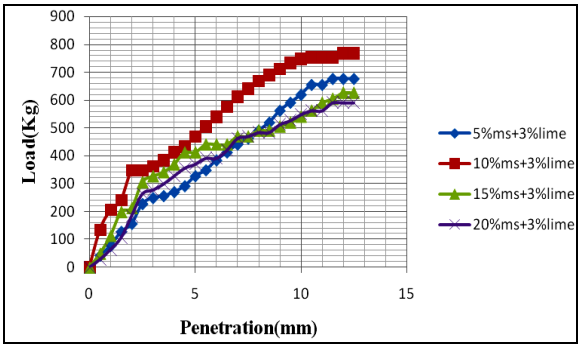

Figure 4. *Load Penetration variation curve at 7 days curing for soil sample*

Table 3: *CBR test results at varying curing periods for soil sample*

Percentage of MS+3%lime	CBR (%)	
	3 Days curing	7 Days curing
5	14.42	20.36
10	18.70	25.46
15	13.11	22.34
20	12.34	19.22

Conclusions

Based on the tests and investigation conducted on soil sample the following conclusions are given as,

The liquid Limit of soil sample is 54%. Soil sample is classified as Highly Compressible clay (CH).The optimum moisture content and maximum dry density of virgin soil sample is 23.5% and 1.39 g/cc. On addition of MS+ lime the maximum dry density decreased to 1.31 g/cc and OMC increases to 25.4%.The unconfined compressive strength (UCS) of untreated soil sample is 0.112 N/mm2. On adding MS with lime the UCC strength increases to 0.622N/mm2 at 10% MS and 3%lime with 14 days curing period and later on decreases when MS percentage increases.

- The California Bearing Ratio (CBR) of virgin soil sample is 3.85. With the addition of 10%MS with Lime the CBR value increased to 25.46 at 7 days curing and later on decreases.
- The strength characteristics UCS and CBR are increasing up to 10%MS with 3%Lime with curing periods and later on decreases when adding more percentage of MS.
- Hence 10%MS with 3%Lime for soil sample is considered as optimum blend percentage for stabilizing this expansive clay.
- The objective of the research is achieved by the addition of Mill Scale and lime by optimum of 10% MS and 3% of lime.
- This can be used in pavement and foundations and construction soil stabilization works.

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